UDOT/FHWA Precast Pavement Panel Showcase

Salt Lake City, Utah – June 7, 2011

National Overview of Precast Concrete Pavement Applications & Findings from SHRP2 Project R05

Shiraz Tayabji

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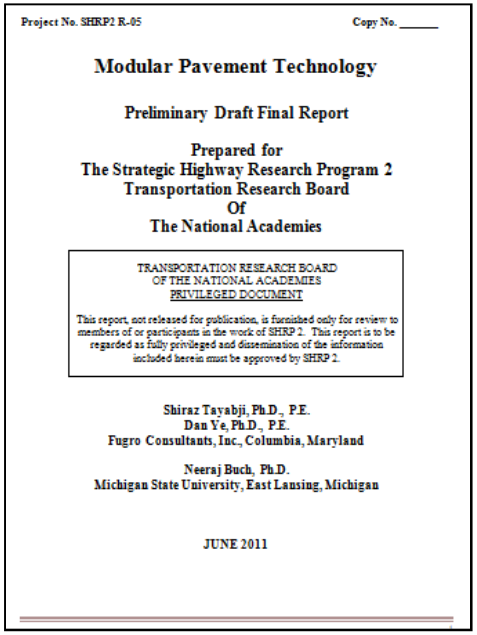
Presentation Outline

- Precast concrete pavement (PCP) background
- PCP systems and applications
- SHRP2 Project R05 scope
- Project R05 findings & products
  - Overall findings
  - Findings based on field testing
  - Guidelines
  - Model specification



Project No. SHRP2 R-05 Copy No. _____

Modular Pavement Technology

Preliminary Draft Final Report

Prepared for
The Strategic Highway Research Program 2
Transportation Research Board
Of
The National Academies

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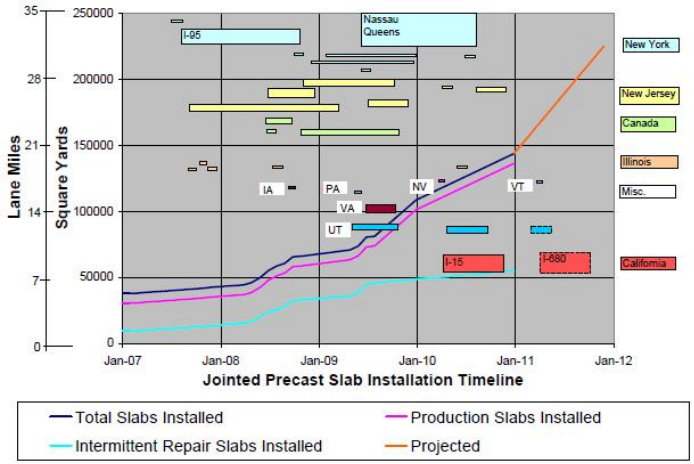
JUNE 2011

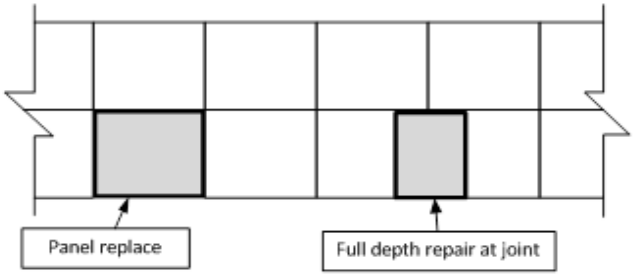
PCP Background

- A recent technology – in use since 2001
- Used primarily for RAPID repair & rehabilitation & longer-lasting treatments
- Typically, night time work & short work windows
- Typically, repair/rehab along a single lane
  - Multiple-lane repair/rehab possible based on site constraints
- Typical production rates/closure
  - 15 to 20 repairs
  - 30 to 40 panels for continuous jointed application (up to 600 ft)
  - Up to 600 ft for PPCP

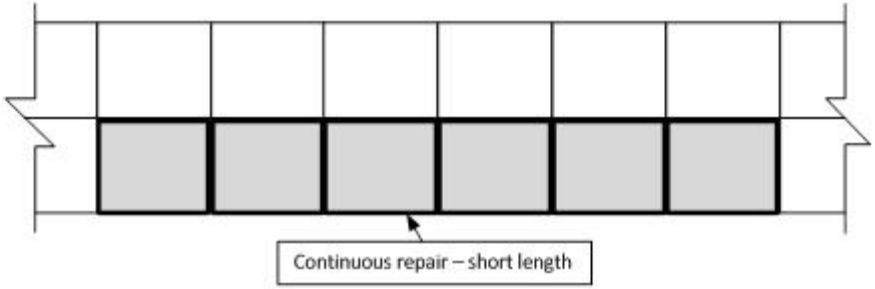


Precast Concrete Pavement (PCP) Applications

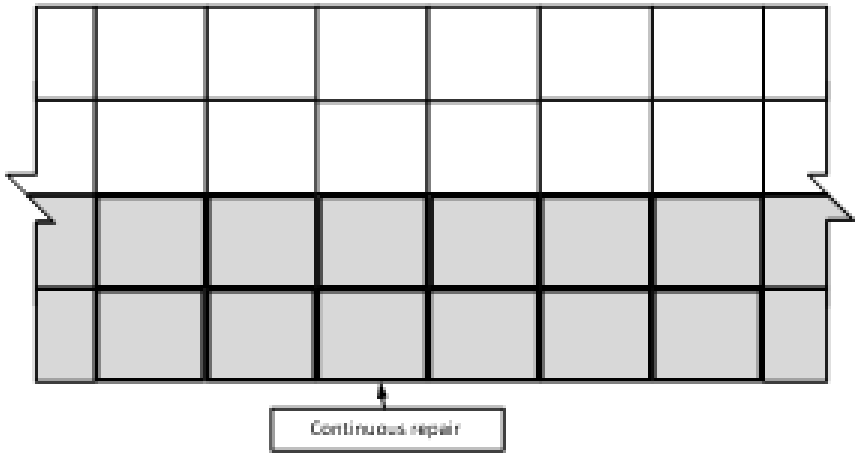
Intermittent Repairs



Shorter Length Rehab



Longer length, Multi-Lane Rehab



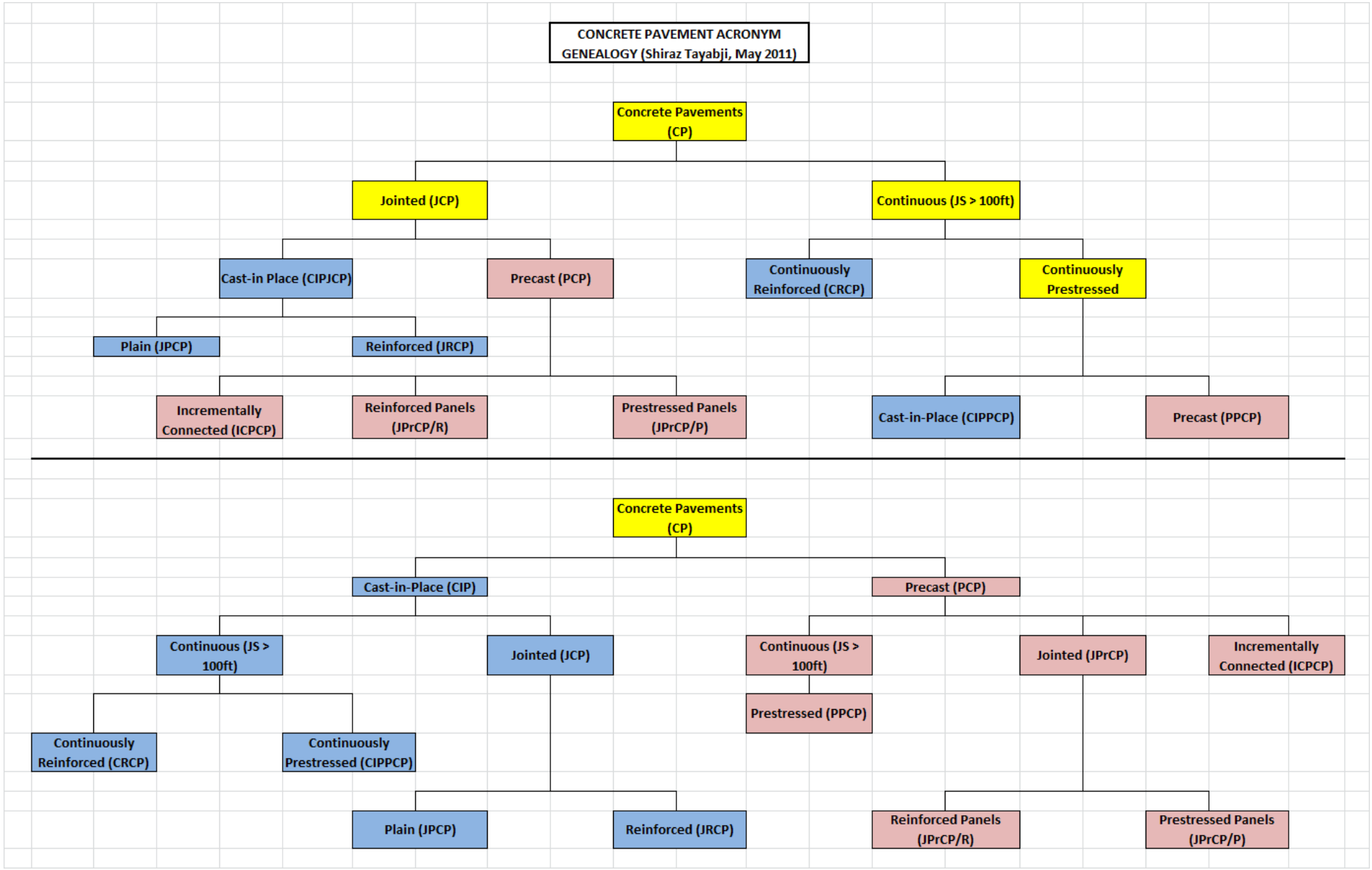
Lane Closure Requirements

- An over-riding assumption is that <u>some level of traffic operation will be maintained</u>
  - o Single-lane repair/rehab – need at least a two-lane closure & at least one lane for traffic
  - o Two-lane repair/rehab – need at least a three-lane closure & at least one lane for traffic
- Otherwise, intermittent full traffic stoppage may be necessary

PCP Systems

- For intermittent repairs
  - Nominally reinforced panels
  - Prestressed panels
- For continuous Applications
  - Jointed PCP systems (JPrCP)
    - Nominally reinforced panels
    - Prestressed panels
  - Post-tensioned systems (PPCP) - fewer active joints; longer sections
  - Incrementally connected PCP (ICPCP)
    - Simulates JRCP – intermediate joints locked-up
    - Fewer active joints; < 100 ft long sections

Generic & Proprietary Systems (Components) Available


CONCRETE PAVEMENT ACRONYM GENEALOGY (Shiraz Tayabji, May 2011)
Concrete Pavements (CP)
Jointed (JCP)
Continuous (JS > 100ft)
Cast-in Place (CIPJCP)
Precast (PCP)
Continuously Reinforced (CRCP)
Continuously Prestressed
Plain (JPCP)
Reinforced (JRCP)
Incrementally Connected (ICPCP)
Reinforced Panels (JPrCP/R)
Prestressed Panels (JPrCP/P)
Cast-in-Place (CIPPCP)
Precast (PPCP)
Concrete Pavements (CP)
Cast-in-Place (CIP)
Precast (PCP)
Continuous (JS > 100ft)
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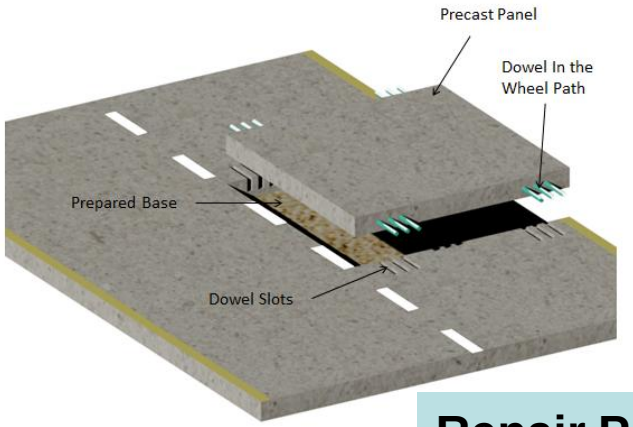
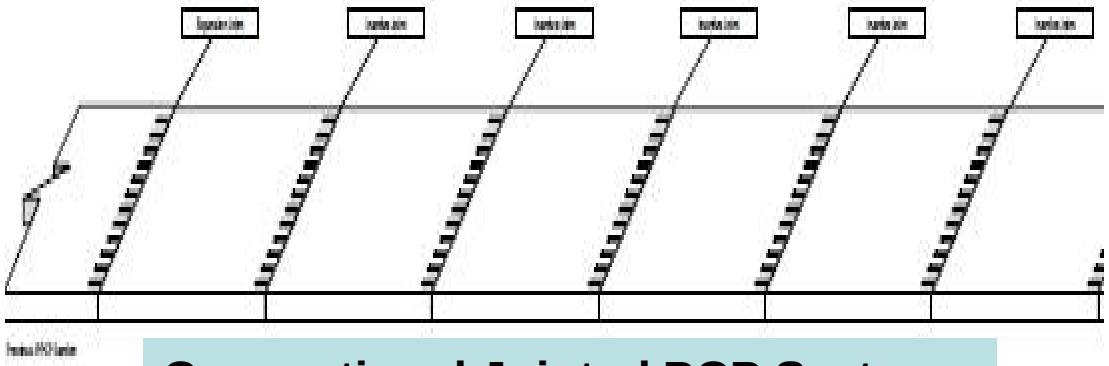
Prestressed Panels (JPrCP/P)

PCP Systems



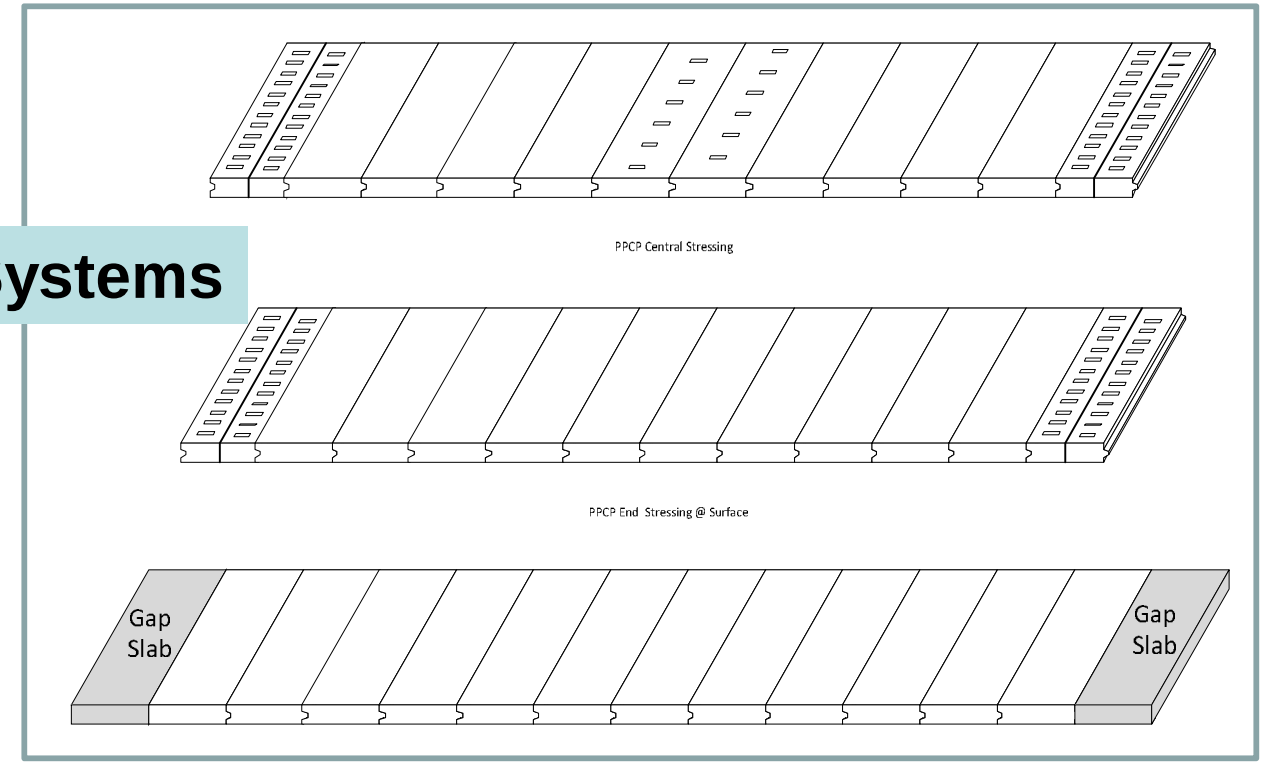
Repair Panels

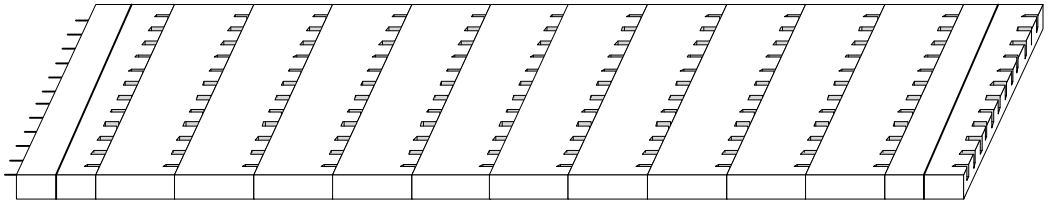


Conventional Jointed PCP System

PCP Systems

PPCP Systems





Incrementally Connected PCP System – Deformed Dowel Bars at Intermediate Joints

PCP Systems

	Precast Jointed (JPCP)	Precast Prestressed (PPCP)	Incrementally Connected (ICJPCP)
Thickness	**Conventional – 10 to 14 in. Prestressed - 8 to 10 in.**	**Thinner - 8 to 10 in.**	**Conventional – 10 to 14 in. Prestressed - 8 to 10 in.**
Active Joint Spacing	**15 ft, typical**	**150 to 300 ft**	**Up to 100 ft**
Active Joint Width, typical	**0.25 to 0.50 in.**	**1.0 to 3.0 in.**	**0.25 to 0.50 in.**
Base Support	**Good support**	**Very Good Support**	**Good to very good support**
Base/Panel Interface	**Bedding layer, if needed**	**Friction reducing treatment needed**	**Bedding layer, if needed**

SHRP2 Project R05

Project Title:

Modular Pavement Technology

Prime Contractor:

Fugro Consultants, Inc.

Subcontractors:

Michigan State University, Dynatest, QES

And, consultants

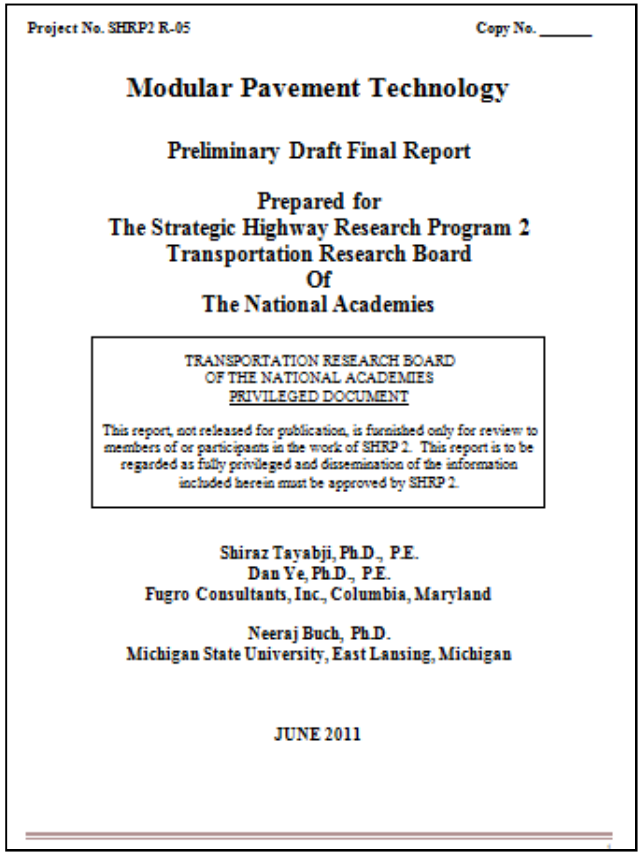
Project objective: To develop guidelines for public agencies to use for the design, construction, installation, and maintenance of precast concrete pavements

SHRP2

STRATEGIC HIGHWAY RESEARCH PROGRAM

Project R05 Final Products

- Overall findings
- Findings based on field testing
- Guidelines for PCP design
- Guidelines for PCP fabrication
- Guidelines for PCP installation
- Guidelines for PCP project selection
- Guidelines for PCP system acceptance
- Model specification



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Key PCP Considerations

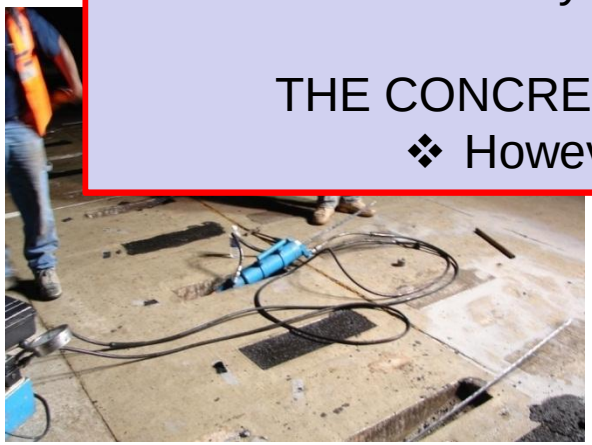
- Constructability (as affected by system design & site conditions)
- Concrete durability
- Pavement performance, as affected by
  - Load transfer at joints
  - Panel support condition

PCPs ARE NOT **"SUPER"** PAVEMENTS; ONCE INSTALLED, PCPs BEHAVE SIMILAR TO CONVENTIONAL CONCRETE PAVEMENTS.

- Only the method of construction is different

THE CONCRETE & THE PANELS AN BE VERY DURABLE

- However, uniform support condition is critical



Overall Findings

- The performance of projects constructed in the US indicate that sufficient advances have been made to reliably achieve the following four key attributes of PCPs:
  - Constructability
  - Concrete durability
  - Load transfer at joints
  - Panel support condition
- However, recent JPrCP projects have exhibited some early-age cracking – design details & construction practices are under investigation by the highway agencies

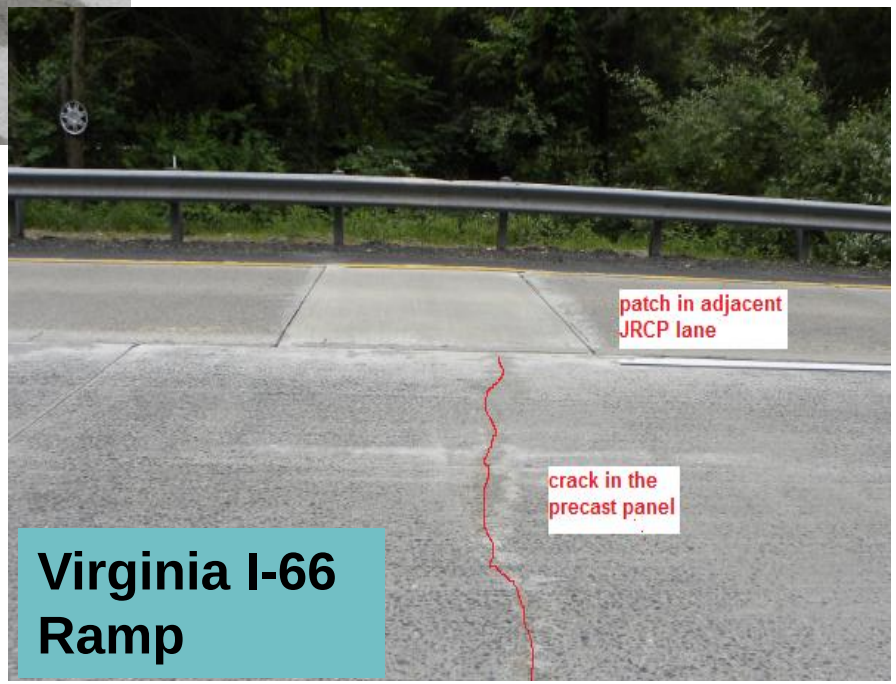
SHRP2 Field Testing

- Field testing performed at 15 PCP projects
  - o Intermittent repairs (6) – IL, MI, NJ, NYS
  - o JPrCP (5) – CA, MN, NJ, NYS, VA
  - o PPCP (4) – DE, MO, TX, VA
- Testing: Deflection, visual, joint elevation, ride

Views of JPrCP Projects

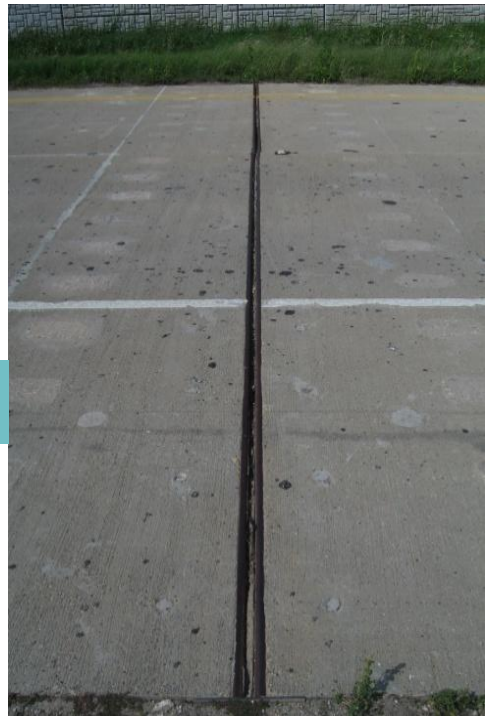
Tappan Zee Bridge Toll Plaza

Minnesota



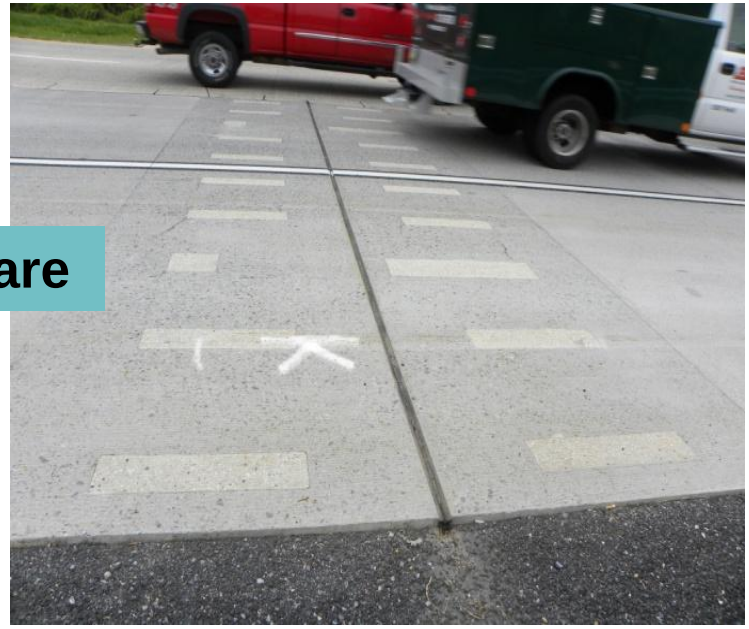
Virginia I-66 Ramp

Texas



Views of PPCP Projects

Delaware



Views of Intermittent Repairs

Michigan
Same Project

Findings Based on Field Testing

- Project R05 deflection testing indicate good load transfer and good deflection response at transverse joints of JPrCP systems used for repair and continuous applications.
- The PPCP systems exhibited higher deflections and lower load transfer at the expansion joints. However, since these expansion joints are 150 to 250 ft apart, the potential for significant joint related distress is low.
- The behavior and performance of the constructed PCP systems appear to be similar to that of like cast-in-place concrete pavements.

SHRP2 Guidelines for PCP Design

PCP Technical Considerations

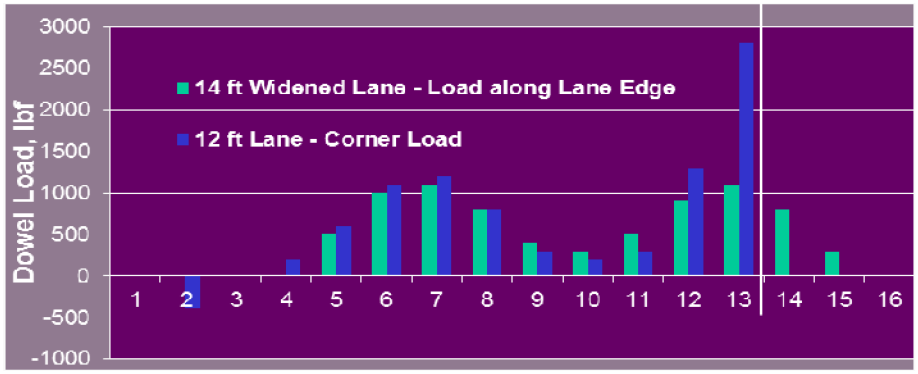
- The guidelines incorporate a range of PCP related topics including:
  - o PCP specific concrete requirements
  - o Jointing and load transfer at joints
  - o Support condition (bedding) requirements
  - o Panel reinforcement
  - o Prestressing related requirements for PPCP
  - o Expansion joint requirements for PPCP
  - o Panel lifting and shipping requirements
  - o Warped panels

SHRP2 Guidelines for PCP Design

- Guidelines have been developed to provide highway agencies defined procedures for design of the PCP systems for the following:
  - Intermittent repair
  - Continuous applications – jointed systems
  - Continuous applications – prestressed systems
- The guidelines are based on practices for CIP concrete pavements, use of the new AASHTO MEPDG, and consideration of differences in the performance of CIP concrete pavements & PCPs.

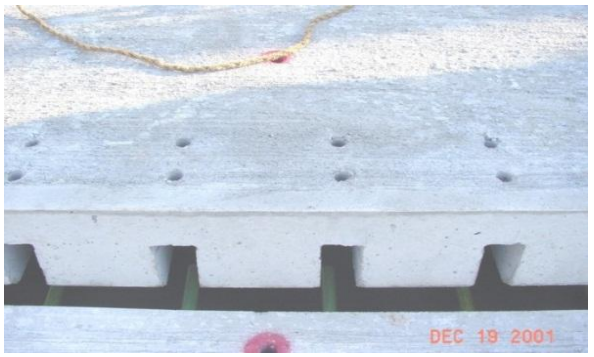
Joint Load Transfer Considerations

- Dowel bar based load transfer system
  - 4 dowel bars per wheel path adequate
  - LTE > 85% at installation
  - Relative defl. < 2 mils for load transfer system approval
- Requires use of dowel bar slots - at panel bottom or at panel surface
  - Full DBR – both sides of joint have surface slots
  - Partial DBR – only one side of joint has slots - at panel bottom or at panel surface



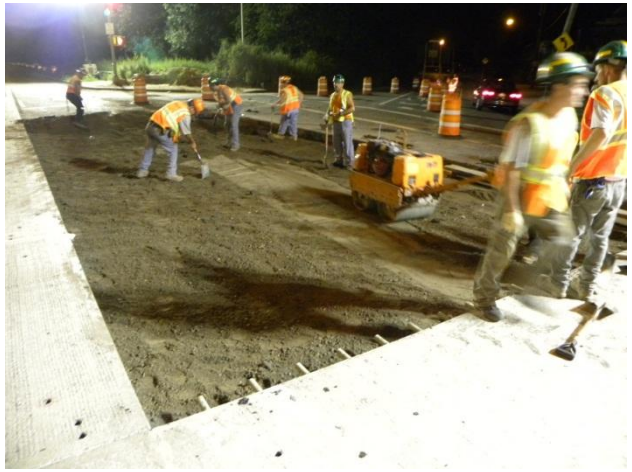
Joint Load Transfer Considerations

- For repairs
  - Method 1: Dowels are drilled and epoxy-grouted along existing pavement sides of joint & dowel slots in panel
  - Method 2: Dowels embedded in the panel & dowel slots cut in existing pavement
  - Method 3: Dowel slots cut in panel & existing pavement
- For continuous applications:
  - Dowels embedded along one side of the panels & dowel slots at other side of the panel (top or bottom)
  - Dowel slots along both sides of the panels



Panel Support Condition

- Use of existing base
  - Granular
    - Reworked, compacted & regraded
    - Reworked, compacted, regraded & bedding material applied



  - Stabilized
    - Used as is or trimmed; bedding material applied
  - Bedding material
    - < ¼ in. fine-grained granular material
    - Thicker layer of RSFF or polyurethane grout
- New base – granular or rapid-setting LCB

Panel Support Condition Issues

- Compaction testing typically not performed on finished granular base/bedding; moisture control not attemp
  - o Use itoring
- Granu uming, requiri grading syster

SHRP2 Guidelines for PCP Design

Jointed PCP Design Considerations

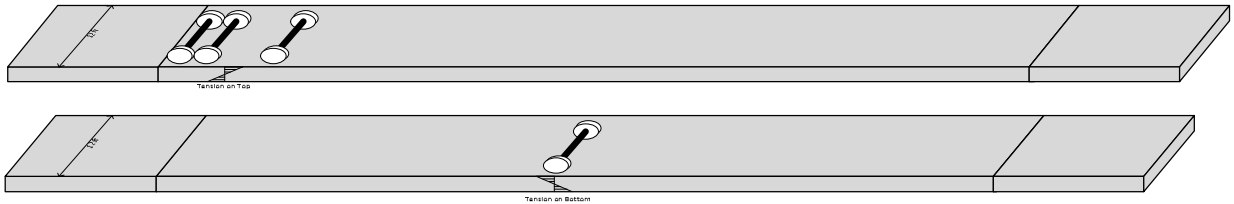
- Design criteria similar to CIP JCPs
  - Cracking - Up to 25% panel cracking as all panels are reinforced/prestressed and cracking will not deteriorate
  - Faulting - Same as for CIP JCP (0.15 to 0.25 in.)
- Concrete strength can be assumed (or specified) to be higher – up to 750 psi
- Jointed PCP thickness
  - Reinforced panels: ~ 1 in. less than CIP JCP
  - Prestressed panels: ~ 3 to 4 in. less than CIP JCP

SHRP2 Guidelines for PCP Design

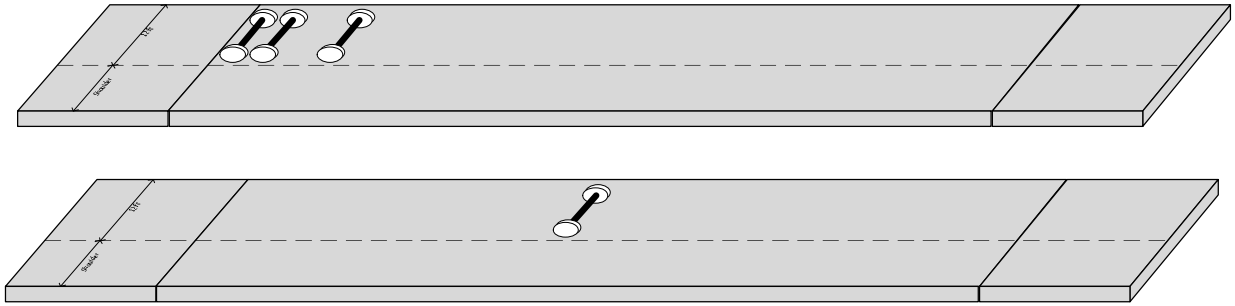
PPCP Design Considerations

- Guidelines for PPCP include computation of prestress losses and determination of effective prestress that allows for thickness reduction
- Thickness – 8 to 9 in. meet most needs
- PT section length = 150 to 250 ft & expansion joints

Edge load condition



Interior Load Condition (BEST FEATURE)



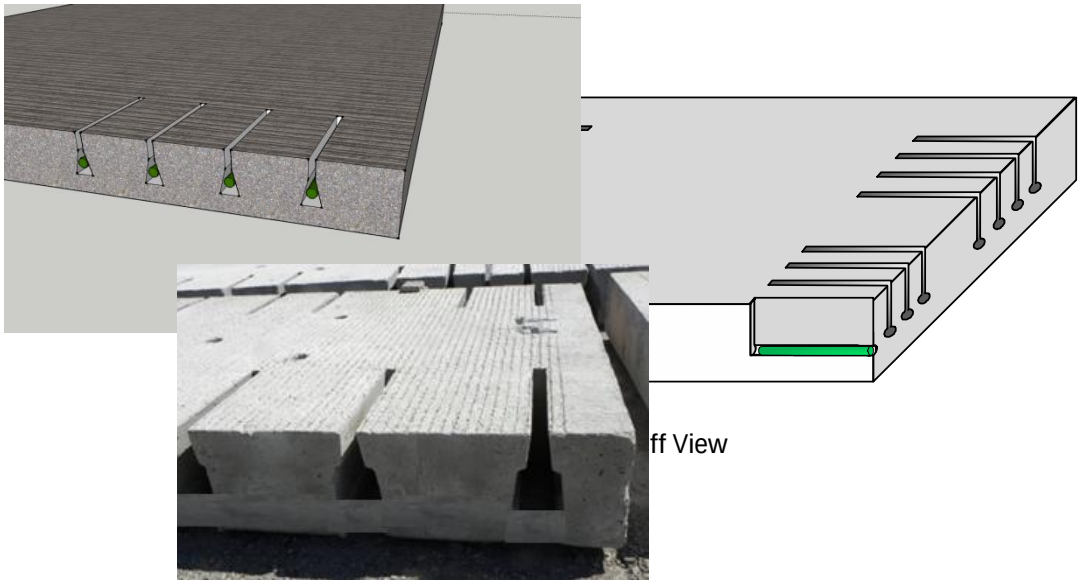
Prestressed PCP Advantage

- For reconstruction of individual lanes of an existing pavement, where slab thickness cannot be changed, prestressed panels offer higher structural capacity within the constraints of existing pavement geometry
  - Using PPCP (post-tensioned system)
  - Using jointed systems with prestressed panels
- For example, a 9 in. PPCP or jointed PCP with prestressed panels is equivalent to 12 to 13 in. CIP JCP long-life design

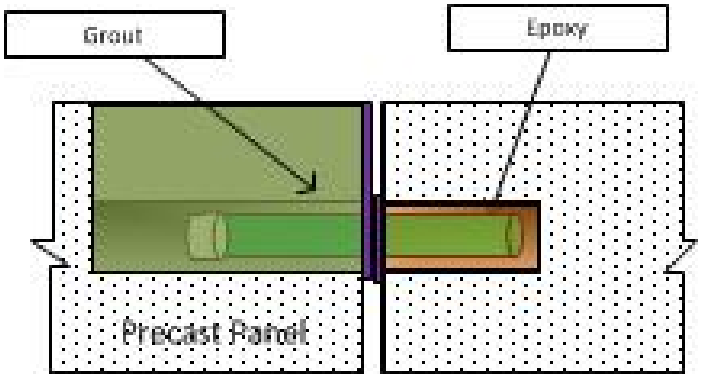
SHRP2 Guidelines for PCP Design

PCP Refinement 1

- Alternate method for installing dowel bars at transverse joints
  - Use of a narrow dowel bar slots at the surface for transverse joint load transfer – allows opening to traffic before the dowel bar slots are patched



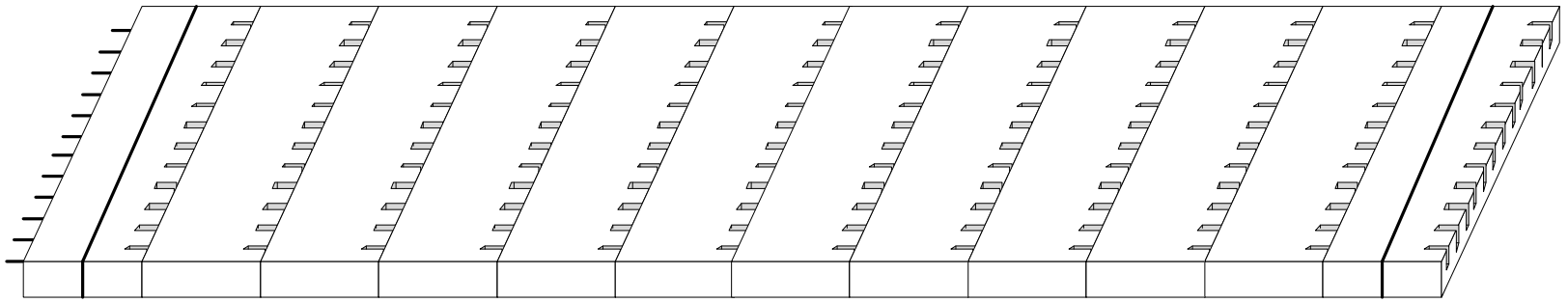
ff View



SHRP2 Guidelines for PCP Design

PCP Refinement 2

- Incrementally connected precast concrete pavement (ICPCP)
  - Use of panels (reinforced or prestressed) that are connected together using mechanical load transfer devices at intermediate (non-active) joints. Simulates JRCP.
- Expansion joints are provided at about 60 to 100 ft.

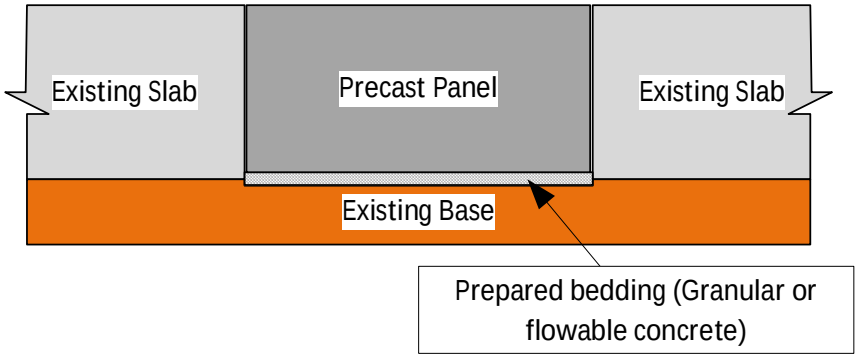


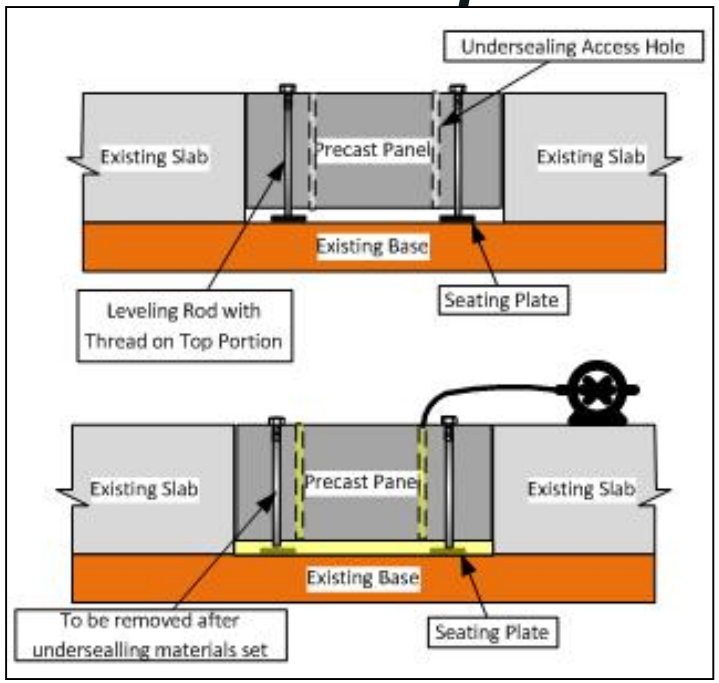
SHRP2 Guidelines for PCP Installation

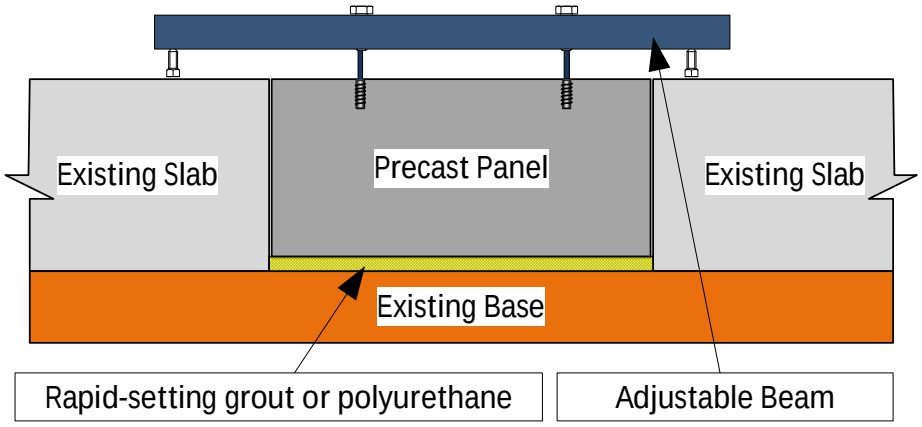
- Guidelines have been developed for installing PCP systems for the following three applications:
  - Intermittent repair
    - Various placement alternatives
  - Continuous applications – jointed systems
  - Continuous applications - PPCP

SHRP2 Guidelines for PCP Installation

Repair Panel Installation Options



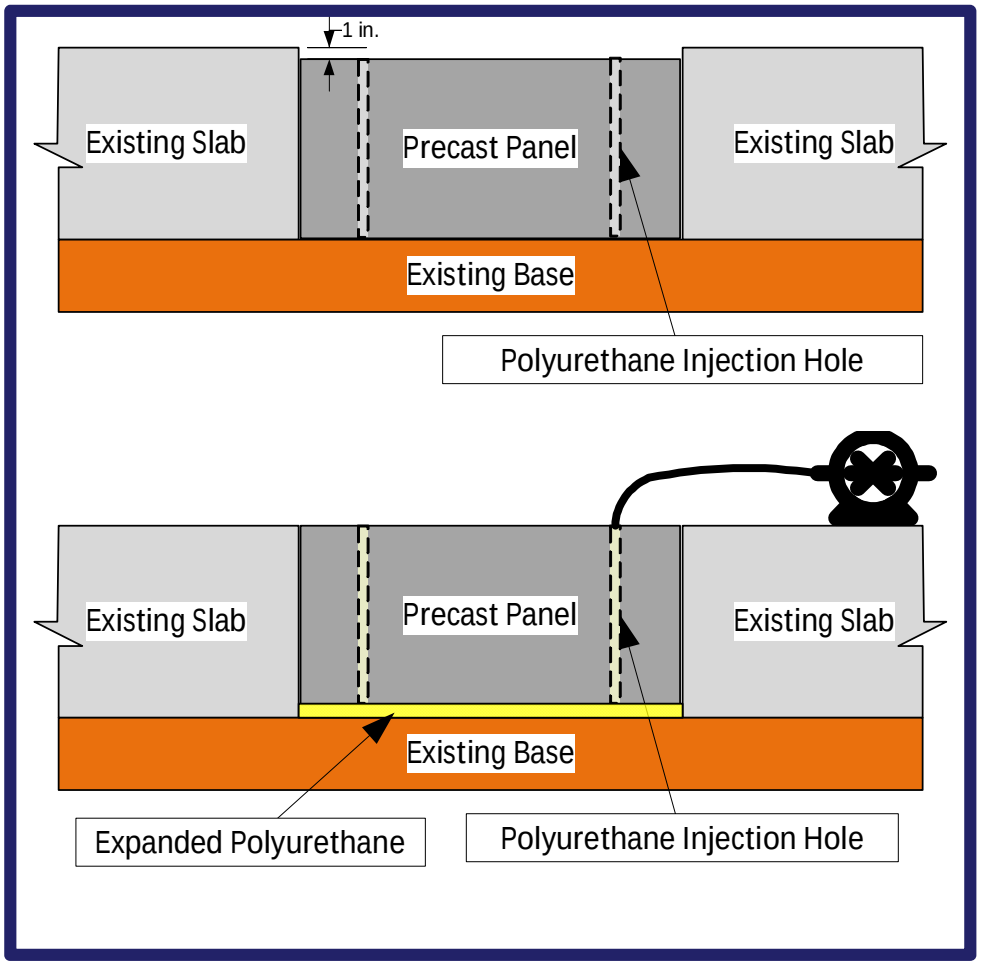




SHRP2 Guidelines for PCP Installation

Repair Installation Options

(Roman Stone Co. Method)



SHRP2 Guidelines for PCP Installation

Guidelines Details

- The guidelines include the following:
  - Maintenance of traffic
  - On-site equipment management
  - Existing pavement removal
  - Base and bedding preparation & TESTING
  - Panel installation
  - Jointing & load transfer provisions
  - Prestressing
  - Emergency management plan
  - QA/QC requirements

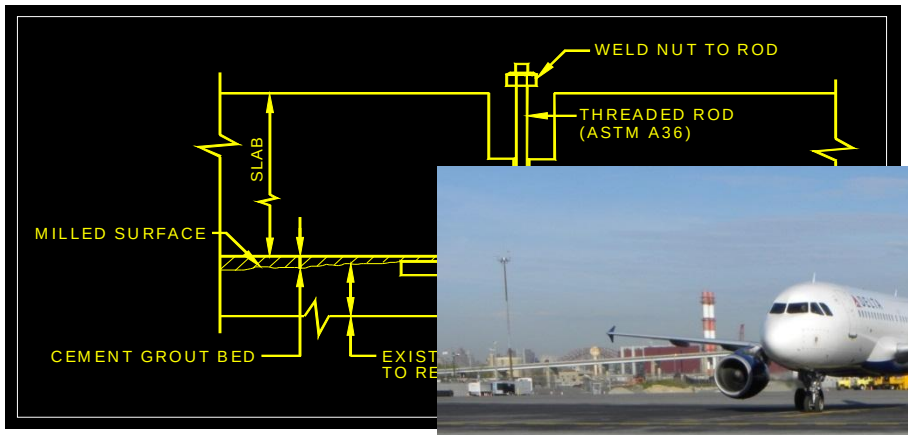
SHRP2 Guidelines for PCP Installation

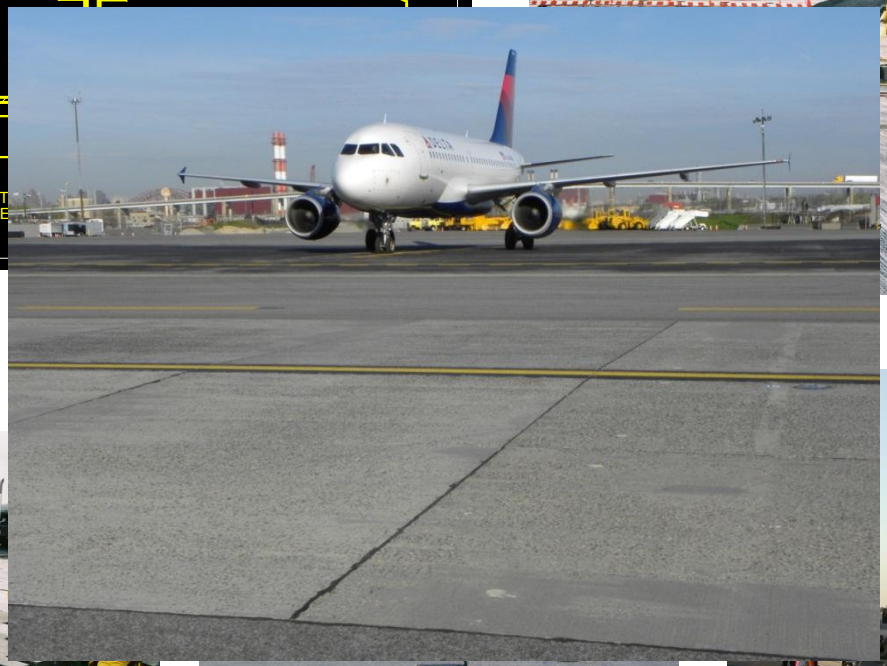
Step by Step Discussion of Installation Process - Continuous Jointed

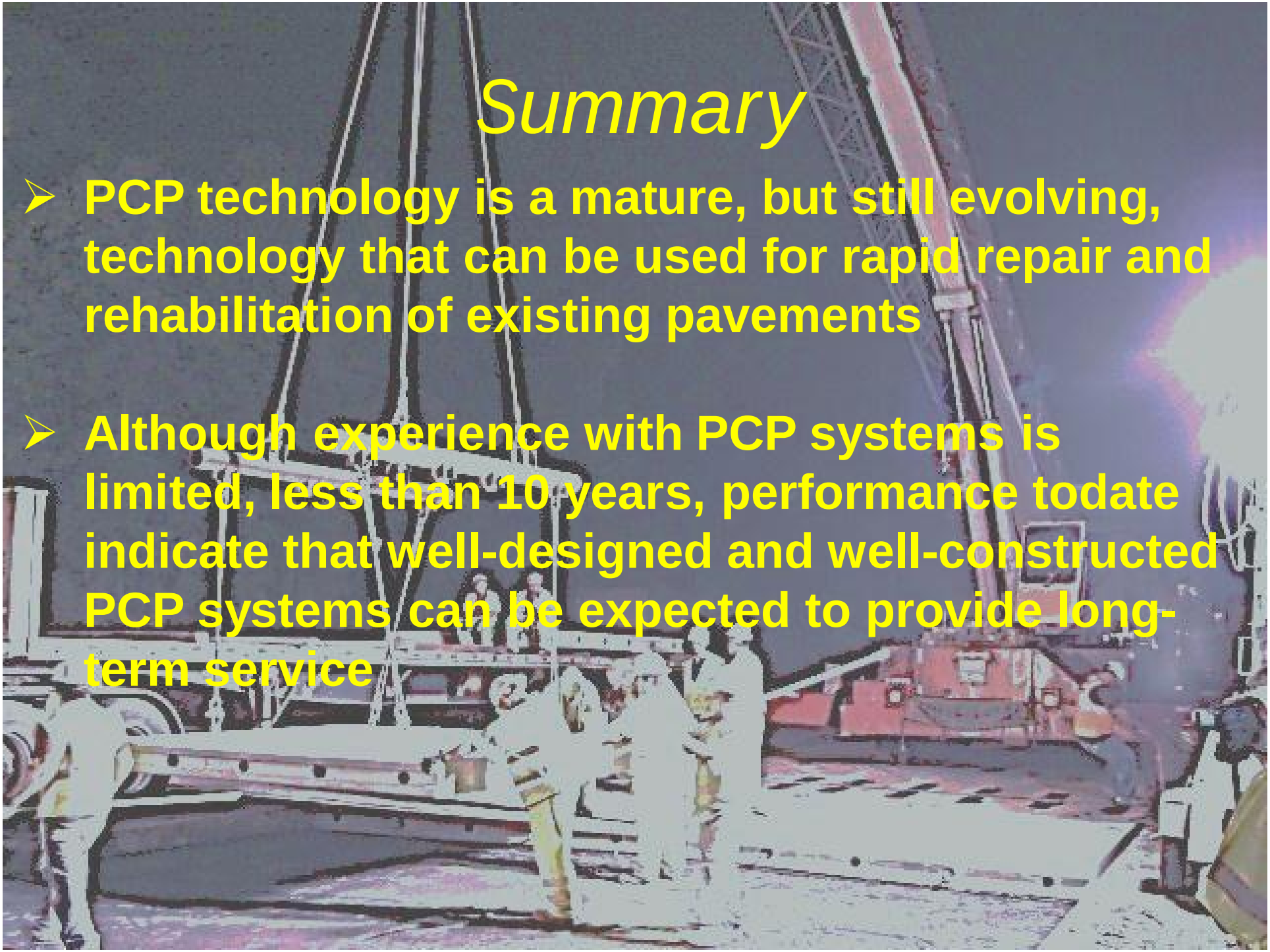
Alternate Installation Process

Panels Set at Desired Elevation (This Open House)

New York's LaGuardia Airport Test sections – Fall 2002







Summary

- **PCP technology is a mature, but still evolving, technology that can be used for rapid repair and rehabilitation of existing pavements**
- **Although experience with PCP systems is limited, less than 10 years, performance todate indicate that well-designed and well-constructed PCP systems can be expected to provide long-term service**